BIOLOGICAL EVALUATION
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EVALUATION OF DOUGLAS-FIR BEETLE IN SHELL CANYON, BIGHORN NATIONAL FOREST, WYOMING

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ABSTRACT

A Douglas-fir beetle outbreak is occurring in Shell Canyon on the Bighorn National Forest. The outbreak has already killed most of the Douglas-fir on the slope across from the Shell Visitor center and appears to be moving up the canyon from there. Without some sort of management actions, it is very likely that up to 70% of the Douglas-fir along the canyon will be killed.

Use of sanitation and salvage harvest is recommended. Opportunities exist to recover wood value and provide a degree of protection to non-timber, high value resource areas.

INTRODUCTION

The Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) infests and kills Douglas-fir (*Pseudotsuga menziesii*) throughout its range in North America. Typically, the beetle reproduces in scattered trees that are highly stressed, such as windfall, defoliated or fire-scorched trees (Furniss, 1962; Furniss, 1965; Lessard and Schmid, 1990). If enough suitable host material is present, beetles can increase in the stressed trees and infest nearby healthy trees (Furniss et al., 1981). Previous research on Douglas-fir beetle infestations have examined forest stand and site characteristics associated with infestations (Furniss et al., 1979; Furniss et al., 1981; Weatherby and Thier, 1993; Negron, 1998), and developed models to predict the extent of tree mortality (Negron et al., 1999). For example, Douglas-fir beetle attacks are most successful on trees that are mature or overmature, largest in diameter, and found in high density stands that contain a high percentage of Douglas-fir in the overstory (Schmitz and Gibson, 1996).

The Douglas-fir beetle has one generation per year (Schmitz and Gibson, 1996). Although adult flight times vary by year, most new attacks occur in early summer on the Bighorn National Forest. Broods develop under the bark throughout the summer and early fall. The overwintering lifestage can be as adults, pupae or larvae. Larvae that overwinter emerge as adults in the summer. A small percentage of adults that overwintered will re-emerge from the spring-attacked trees and attack additional trees in the middle of the summer.

Noticeable tree mortality caused by Douglas-fir beetle started to appear in Shell Canyon in 2001. Mortality has continued to increase, and this year there are larger spots of mortality evident. There is no known disturbance event, such as windthrow or fire, which would have caused this increase. This is a highly visible area, one of the byways leading down the west face of the Bighorn Mountains.

METHODS AND MATERIALS

One method of determining infestation level trends is through transect lines that count the number of green infested trees and previously killed trees. Lines are typically ½ to 2 miles long and a chain wide. Each quarter mile of transect equals 2 acres of coverage. Trees

infested with or previously killed by Douglas-fir beetle are counted and then comparisons can be made between the number of trees infested each year. This gives a rough beetle population trend. Three such transects, ranging from 1 to 1 and ¼ mile long were done in Shell Canyon in early August 2003. One transect was along the bench trail between the Pussyfoot timber sale and the old tornado/blowdown area. The second transect was along the bench trail between the tornado area down towards the Shell Visitor Center. The third was done on the lower part of the slope across the highway from the Shell Visitor Center.

On August 6, 2003, 6 inch by 6 inch bark samples were removed from the north and south sides of currently infested Douglas-fir trees. Brood sampling was done on a total of 38 trees. Samples were taken at DBH. There was no difference between north and south samples, and so those numbers have been combined. Samples were taken from along the bench trail in Shell Canyon. Diameter at breast height was recorded for each sample tree. The measurements taken for each sample included: Number and life stage of live DFB, number of gallery starts, and number of each of three natural enemies of DFB (Clerids, *Coeloides*, and *Medetera*).

RESULTS AND DISCUSSION

Table 1 shows the number of beetle attacked trees on each transect line. The area between the tornado and Shell Visitor Center is being highly impacted at this time, while the area between the Pussyfoot timber sale and the tornado area is presently only lightly attacked. It appears that the infestation started down lower in the canyon and is working its way up. The area below the tornado, which is most heavily impacted right now, already has over one third of the trees per acre killed by Douglas-fir beetle. It is also of note that in this area, 80% of the attacked trees are currently infested and will be producing beetles next year. The beetle population is continuing to increase and kill trees at a high level.

Table 1. Number of trees attacked per acre by Douglas-fir beetle along with average tree diameter and trees per acre in Shell Canyon.

Transect	Location	CY	1yr	2yr	Total	DBH	TPA	Trees Killed per Acre	% TPA KILLED
1	Bench-pre tornado	10	0	0	10.0	13.0	208.0	1.0	0.5%
2	Bench-post tornado	906.0	102.0	30.0	1038.0	14.0	304.0	103.8	34.1%
3	Shell Visitor center	674.0	221.0	42.0	937.0	11.1	275.0	114.1	42.5%
Sum		**1590**	**323**	**72**	**1985**				
Average		**530.0**	**107.7**	**24.0**	**661.7**	**12.7**	**262.3**	**70.9**	**25.7%**

Table 2 lists the number of beetle killed trees found on all transects. It also shows a ratio of attack frequency between years, an estimate of how fast the population is building. Higher ratios mean that there are more trees being attacked in each subsequent year. In Shell Canyon, the ratios indicate the population has been increasing 4 to 5 times a year the last 3 years. The comparison from 2001 to 2003 (2-year old dead trees to currently infested trees) indicates an over 20-fold increase in beetle caused mortality.

Table 2. Number of Douglas-fir beetle attacked trees along 3 ½ miles of transect in Shell Canyon, and the ratio of attack frequency between years.

Year	Total Trees Attacked	Attacked Trees per Acre
2001 Dead	72	2.6
2002 Dead	323	11.5
Green Infested	1590	56.8
Total	**1985**	**70.9**

Ratio of Attack Frequency Between Years

2001:2002	1:4.5
2002:2003	1:4.9
2001:2003	1:22

Average tree diameter at the 2 brood sample sites was 16.6 and 15.1 inches. There were 1926 live DFB brood found in the samples taken, of these, 221 were new adults, 50 were pupae, and 1655 were larvae or eggs. Most of the larvae were mid to late instar. There were a few trees that had eggs from late summer attacks. This means there was an average of 25.3 live brood per sample. The average number of gallery starts per sample 2.6. There were a total of 14 natural enemies found in the 76 samples, 12 wasps (*Coeloides*) and 2 flies (*Medetera*). Brood samples taken in another month or 2 may have a few more natural enemies show up, but overall it is apparent that natural control agents are overwhelmed and will not be able to check the Douglas-fir beetle population.

Population trends can be estimated by dividing the density of emerging beetles by twice the density of gallery starts (attacks), assuming that a pair of beetles initiates each gallery start. When the ratio of emergence to attack exceeds one, the population is increasing and when the ratio is less than one the population is decreasing. The ratio in this area is 4.9:1 for emerging to attacking, indicating that the population is in fact increasing strongly.

Maximum brood production takes place when gallery starts average between 1 and 2 per 6”x6” sample, or 4 to 8 in a square foot (McMullen and Atkins 1961). The average for Shell Canyon is 10.78 per square foot. This gives another indication that beetles are producing offspring at a high rate and the population is increasing.

Although much of the brood is currently larvae, they will continue to mature for another month to 6 weeks this summer. It is most likely that most of the brood will overwinter as new adults.

CONCLUSIONS AND RECOMMENDATIONS

If no management actions are taken this Douglas-fir beetle outbreak will continue to grow, there will be further reductions in overstory basal area and average tree diameter across the landscape. Based on the levels of mortality that have occurred to date, losses of up to 70% or higher of the Douglas-fir in areas of heavy tree mortality could occur. The area by the visitor center is already approaching 50% loss. Regeneration and forage production should increase in beetle-caused openings in the forest. The majority of the regeneration should continue to be Douglas-fir and smaller percentages of spruce, fir, and pine.

The entire canyon is going to change character in the near future. There will be a heavy loss of mature forest that will be easily visible from the highway. In the short term, the hillside will consist largely of red, and then gray dead trees. In the longer term, there will be large openings and over time a young forest returning to the landscape.

For areas of the forest where control of Douglas-fir beetle is warranted, the following recommendations are offered:

Salvage/sanitation harvesting

Sanitation harvesting involves removing currently infested trees from the site. Removal of these infested trees can decrease a localized beetle population. Sanitation harvesting should be completed before the beetles start to emerge in May of each year. In addition, in stands that have been heavily attacked and mortality has been high, salvaging dead trees to capture some economic value in the near future is appropriate. However, salvage harvesting does not reduce beetle populations.

Most of the area between the tornado and the visitor center is in advanced stages of a beetle epidemic and the only real treatment available is salvage. It would reduce the dead fuel load in this area, it would remove large amounts of dead material from the site helping with regenerating the area, and it could capture some economic return from the trees harvested.

An aggressive sanitation effort is recommended in the area between the Pussyfoot timber sale and the tornado. This area is just starting to have Douglas-fir beetle attacks show up, and an aggressive sanitation effort, combined with general thinning may be enough to save some of the large overstory trees and maintain the forested appearance. These efforts should take place in the next 2-3 years to be effective. Any time after that and it will likely turn into a situation similar to that farther down the canyon where the only option is salvage.

Being that Douglas-fir beetle attacks are most successful in overstocked stands that contain a high percentage of large diameter Douglas-fir, silvicultural treatments that alter these stand conditions will reduce a stand's susceptibility to attack and potential wide-spread damage. Preventative silvicultural treatments, such as thinning, are used in stands that have not yet been affected by the beetle to reduce susceptibility to attack. It should be part of an ongoing vegetation management program to help increase the health of stands by decreasing their vulnerability to any insects and diseases, not just Douglas-fir beetle. To reduce the susceptibility of stands to Douglas-fir beetle, basal area should be below 80% of normal stocking (Furniss et al. 1981). Harvesting in old, mature stands and thinning younger stands could be used to create healthier stand conditions where it is appropriate.

High value areas/Non-timber treatments

Douglas-fir beetle has a well-studied complex of pheromones (message-bearing chemicals), which it emits to regulate the behavior of other beetles. Anti-aggregation pheromones, such as MCH, serve to disrupt aggregation behavior of beetles (Schmitz and Gibson, 1996). MCH has been used experimentally to reduce the level of attack in high-risk areas (Ross and Daterman, 1994, 1995). In addition, the use of MCH can be combined with aggregation pheromones that are attached to funnel traps located outside areas of high value to reduce beetle population. Another alternative is to concentrate attacks on certain trees by using the aggregation pheromones and to remove those trees (i.e., trap tree method), thereby lowering the beetle population in a localized area.

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Being that Douglas-fir beetle attacks are most successful in overstocked stands that contain a high percentage of large diameter Douglas-fir, silvicultural treatments that alter these stand conditions will reduce a stand's susceptibility to attack and potential widespread damage. Preventative silvicultural treatments, such as thinning, are used in stands that have not yet been affected by the beetle to reduce susceptibility to attack. It should be part of an ongoing vegetation management program to help increase the health of stands by decreasing their vulnerability to any insects and diseases, not just Douglas-fir beetle. To reduce the susceptibility of stands to Douglas-fir beetle, basal area should be below 80% of normal stocking (Furniss et al. 1981). Harvesting of old, mature stands and thinning younger stands could be used to create healthier stand conditions where it is appropriate.

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